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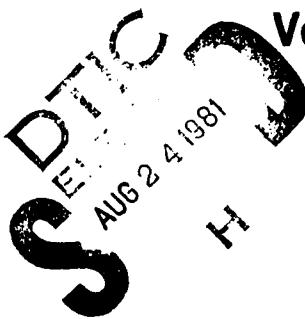
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THE IMPLEMENTATION OF TESTABILITY
INTO MILITARY EQUIPMENT

Volume 2: Appendices



D.D. Hall

30 April 1981

Final Report: July 1980 - April 1981

Prepared for
Chief of Naval Material

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NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

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ADMINISTRATIVE INFORMATION

This technical document describes a plan for the implementation of testability into military equipment via the military specification process. The plan was developed by personnel of the Information Transfer Division (NOSC Code 825) in support of the Naval Ocean Systems Center Test Technology Office. This technical document incorporates analysis performed by ManTech International Corporation, under contract N00123-79-C-0422 under O&MN funding. The principal investigator for ManTech was Mr. T. C. Chapman. Mr. A. C. MacMurray was the Contracting Officer's Technical Representative.

Released by
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Test Technology Office

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| 20 ABSTRACT (Continue on reverse side if necessary and identify by block number) A plan for the development and modification of military standards, specifications, and handbooks for the purpose of making the design discipline of testability a reality in equipment procurements and designs has been developed. This plan is based on an analysis of existing related documents and a "systems approach" to the problem of management and control of this design area via the specification process. The overall problem was segmented into six functional areas for solution which is presented in the form of specific recommendations for each area. It is intended that the plan be used as the foundation for a program to develop the documents needed to make testability happen in military equipment. This plan could also serve as a model for similar efforts in other design areas. (Contd.) | | | |

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20. ABSTRACT (Continued)

This technical document is provided in two volumes. Volume 1 presents the description of the problem, work accomplished, and results. The results are presented as general recommendations for creation, modification, or deletion of specific military documents. Volume 2 contains supporting appendices that provide more detailed recommendations for modification of some existing documents as well as supporting analytic material.

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APPENDIX A

DOCUMENT SURVEY

DOCUMENT SURVEY

SURVEY

As specified in the Task Statement for this task, the following (22) testability-related documents were surveyed:

| <u>Document</u> | <u>Title</u> |
|--|--|
| MIL-STD-415D 1 October 1969 | Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for |
| MIL-STD-470 21 March 1966 | Maintainability Program Requirements |
| MIL-STD-471A 27 March 1973 | Maintainability Verification/Demonstration/Evaluation |
| MIL-STD-721B 25 August 1966 | Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety |
| MIL-STD-756A 15 May 1963 | Reliability Prediction |
| MIL-STD-757 19 June 1964 | Reliability Evaluation from Demonstration Data |
| MIL-STD-781C 21 October 1977 | Reliability Design Qualification and Production Acceptance Tests; Exponential Distribution |
| MIL-STD-785A 28 March 1969 | Reliability Program for Systems and Equipment Development and Production |
| MIL-STD-1326 15 January 1968 | Test Points, Test Point Selection and Interface Requirements for Equipment Monitored by Shipboard On-Line Automatic Test Equipment |
| MIL-STD-1345A(EC) 21 March 1975 | Data, Measurement, in Support of Maintenance, Calibration, and Repair of Electronic Equipment |
| MIL-STD-1364E(NAVY) 1 April 1979 | Standard General Purpose Electronic Test Equipment |
| MIL-STD-1390B(NAVY) 1 December 1976 | Level of Repair |
| MIL-STD-1519(USAF) 1 August 1977 | Test Requirements Document, Preparation of |

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|---|--|
| MIL-STD-1657(SH) 30 April 1980 | Switching Equipment, Combat System, Command and Control, and Fire Control, Requirement for |
| MIL-STD-2076 1 March 1978 | UUT compatibility with ATE, General Requirements for |
| MIL-STD-2077(AS) 9 March 1978 | Test Program Sets, General Requirements for |
| MIL-T-24309(SHIPS) 1 September 1967 Amendment 2 29 December 1967 | Technical Support Plan for Electronic Equipment |
| MIL-T-28800B 9 February 1976 | Test Equipment for Use with Electrical and Electronic Equipment, General Specification for |
| NAVMATINST 3960.9A 23 April 1979 | Built-In-Test (BIT) Design Guide |
| MIL-STD (number to be assigned) 15 February 1980 | Testability Standardization for Electronic Systems and Equipment, W. Keiner |
| MIL-HDBK-217C 9 April 1979 | Reliability Prediction of Electronic Equipment |
| MIL-HDBK-472 24 May 1966 | Maintainability Prediction |

The individual surveys of the documents are formatted in the following categories:

- o Major topics
- o Level of detail
- o Area of coverage
- o Constraints
- o Overlap between documents
- o Contributions toward testability

Major Topics

This paragraph outlines the scope of the document.

Level of Detail

An indication of the depth of coverage of the document is shown in this paragraph.

Area of Coverage

This paragraph reflects the area of usage for the document:

- o Management of test programs
- o Requirements for hardware (UUT, ATE/on-line unit)
- o Implementation (Design Guide)
- o Documentation of testability (design review data, configuration, etc.)
- o Proof of testability in the form of demonstration tests.

Constraints

In this paragraph are shown any restrictions as to applicability of the document to such things as on/off-line testing, using agency, type of hardware, etc.

Overlap Between Documents

This paragraph identifies the other document(s) reviewed that contain the same type of information.

Contribution Toward Testability

This paragraph shows how the document contributes toward the testability of hardware. Example: the document specifies the format for presenting interface data between the UUT and ATE.

Document: MIL-STD-415D

Date: 1 October 1969

Title: Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for

User: Air Force

Major Topics: On-Line and Off-Line Design Criteria

Level of Detail:

Establishes design criteria for test provisions to monitor, evaluate, or isolate electronic systems to support maintenance concept.

Area of Coverage:

The primary area of coverage is the design requirements of test provisions. Additional coverage is given on how to implement the standard on contracts and what data would be required.

Constraints:

Only applicable to test provision design criteria for electronic systems and associated equipment.

Overlap Between Documents:

General overlap in the area of test points and BIT in the proposed MIL-STD (W. Keiner).

Contribution Toward Testability:

The document supplies general design criteria.

NOTES

MIL-STD-415D, 1 October 1969, Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for

User: Air Force

General Requirements:

This standard establishes design criteria for test provisions that permit functional and static parameters of electronic systems and associated equipment to be monitored, evaluated, or isolated. These test provisions consist of: external test receptacles; built-in test; and test points. These test provisions are to provide adequate support to a defined maintenance concept.

Classification of Test Provisions:

Classified as to the item level of maintenance they are to support;

- o Class A Item Performance
- o Class B Isolate Malfunctions to a Replaceable Unit (RU)
- o Class C Isolate Malfunctions to a Replaceable Module (RM) or Assembly
- o Class D Isolate Malfunctions to an Individual Circuit and Piece Part Level

Contractor Analysis:

Contractor determines the test provisions after analyzing item design to ensure they meet the maintenance concept.

Quality Assurance (QA):

Test provisions QA procedures are to meet those specified for the item of which they are a part.

Detailed Requirements:

The requirements are stated in fairly general terms with only one other document being referenced (MIL-STD-1472).

Document: MIL-STD-470

Date: 21 March 1966

Title: Maintainability Program Requirements

User: DOD

Major Topics: Maintainability

Level of Detail:

This MIL-STD is concerned with establishing a maintainability program and the guidelines for preparation of a maintainability program plan.

Area of Coverage:

The area of coverage is the management of a maintainability program.

Constraints:

None.

Overlap Between Documents:

There is overlap and possible conflict with the proposed MIL-STD (W. Keiner) in introducing "Testability" as a design discipline where maintainability has been the classical approach.

Contribution Toward Testability

The document provides the base for an overall design discipline which bounds the design (MTTR parameters).

NOTES

MIL-STD-470, 21 March 1966, Maintainability Program Requirements

User: DOD

This MIL-STD is concerned with establishing a maintainability program and the guidelines for preparation of a maintainability program plan. The maintainability program plan is normally a data item (CDRL) that is submitted for approval at the start of a hardware design program.

Document: MIL-STD-471A

Date: 27 March 1973

Title: Maintainability Verification/Demonstration/Evaluation

User: DOD

Major Topics: Maintainability Demonstration

Level of Detail:

The MIL-STD specifies methods of test implementation, pass/fail criteria, and test reporting.

Area of Coverage:

The MIL-STD deals in the proof of testability in the form of demonstration tests.

Constraints:

Only applied during DT&E and OT&E.

Overlap Between Documents:

There is overlap and possible conflict with the proposed MIL-STD (W. Keiner) in the demonstration test area. The time for the test equipment to detect, isolate, and retest is part of the maintainability MTTR demonstration test.

Contribution Toward Testability:

The document provides a method of proving by test that the hardware is maintainable. This also proves that the test equipment can test, detect, and isolate failures.

NOTES

MIL-STD-471A, 27 March 1973, Maintainability Verification/Demonstration/Evaluation

User: DOD

The MIL-STD is concerned with the maintainability, demonstration, and evaluation during Phases I, II, and III. These three phases are:

- o Phase I (Verification) during DT&E.
- o Phase II (Demonstration) during DT&E or OT&E.
- o Phase III (Evaluation) during OT&E.

Verification is based on all available data (prediction, data from other tests, etc.).

Demonstration is based on a contracted test that simulates actual conditions with simulated faults.

Evaluation is based on actual performance in the operational and maintenance environments.

The MIL-STD spells out all aspects of conducting a maintainability test; the primary area being the demonstration. This includes the test plan to the test report.

Appendix A

This appendix depicts the method of task sampling for failure simulation. The task sampling is based on failure rate distribution. The module that fails the most often is allotted a greater percentage of the total number of failure simulations.

Appendix B

This appendix depicts the test methods that may be used or specified by the Procuring Activity. These test methods are the math portion of the test with pass/fail criteria.

The relationship to testability is as follows:

The ATE or test equipment specified in the test procedure works as expected or doesn't. This includes any associated software and maintenance manuals. The use of the test equipment and manuals by the expected technician skill level is the primary objective of a maintainability demonstration.

Document: MIL-STD-721B

Date: 25 August 1966

Title: Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety

User: DOD

Major Topics: Definitions

Level of Detail:

General Definitions

Area of Coverage:

The definitions are related to reliability, maintainability, human factors, and safety.

Constraints:

Only addresses reliability, maintainability, human factors, and safety.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides maintainability definitions which relate to testability.

NOTES

MIL-STD-721B, 25 August 1966, Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety

User: DOD

This MIL-STD is a dictionary of terms commonly used in the areas of reliability, maintainability, human factors, and safety.

Document: MIL-STD-756A

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Date: 15 May 1963

Title: Reliability Prediction

User: DOD

Major Topics: Prediction of Hardware Reliability

Level of Detail:

This MIL-STD specifies how to perform a reliability prediction and references MIL-STD-217 for electronic failure rates.

Area of Coverage:

This MIL-STD's area of coverage deals with the methodology of documentation.

Constraints:

The document is only applicable to systems and subsystems that are subject to failure; primarily for electrical and electronic hardware.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The MTBF figures are used to determine demand rates for test equipment.

NOTES

MIL-STD-756A, 15 May 1963, Reliability Prediction

User: DOD

The MIL-STD outlines the methods of performing (1) feasibility prediction procedures, and (2) design prediction procedures. The methods are presented as a step-by-step procedure.

The MIL-STD is related to testability by the use of failure rates that are converted to mean-time-between-failure (MTBF) figures. Those MTBF figures are used to calculate the demand rate for the ATE/test equipment.

Document: MIL-STD-757

Date: 19 June 1964

Title: Reliability Evaluation from Demonstration Data

User: DOD

Major Topics: Reliability

Level of Detail:

Utilizes achieved reliability data to make mission reliability projections.

Area of Coverage:

The area of coverage is as follows:

- (a) Implementation as a system design tool.
- (b) Documentation of reliability study results.

Constraints:

This document is only usable with achieved reliability data.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The MTBF figures are used to determine demand rates for test equipment.

NOTES

MIL-STD-757, 19 June 1964, Reliability Evaluation from Demonstration Data

User: DOD

The MIL-STD is concerned with projections of mission reliability by utilizing achieved reliability of hardware sub-units. The achieved reliability is expressed in failure rates which are the reciprocal of the MTBF.

This relates to the test engineer in the area of MTBF figures which are used to develop demand rates for use of ATE/test equipment. The mission related (time) reliability figures are utilized in life-cycle costs (LCC) and level-of-repair (LOR) studies.

Document:

MIL-STD-781C

Date:

21 October 1977

Title:

Reliability Design Qualification and Production Acceptance Tests; Exponential Distribution

User:

DOD

Major Topics: Reliability Testing

Level of Detail:

Specifies the test plans, procedures, and data required to demonstrate the reliability of hardware. The test plans include the pass/fail criteria.

Area of Coverage:

This MIL-STD deals with the proof of reliability.

Constraints:

This document only addresses equipment that experiences a distribution of time-to-failure that is exponential, as is normally associated with electronic hardware.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides for the proof of the MTBF figures by test. The MTBF figures are used to determine demand rates for test equipment.

NOTES

MIL-STO-781C, 21 October 1977, Reliability Design Qualification and Production Acceptance Tests; Exponential Distribution

User: DOD

This MIL-STD specifies the test plans (pass/fail criteria) for the reliability demonstration of equipment that experiences a distribution of times-to-failure that is exponential. Also includes test conditions, procedures and reports.

The relationship to the test engineer is in the area of MTBF. The MTBF figures resulting from the testing have a higher confidence than those obtained from reliability prediction. The MTBF figures are used to project demand rates for ATE/test equipment.

Document: MIL-STD-785A

Date: 28 March 1969

Title: Reliability Program for Systems and Equipment Development and Production

User: DOD

Major Topics: Reliability Programs

Level of Detail:

This MIL-STD specifies sub-tier documents; specifies the general contents for a reliability program plan, and the types of data required for submittal to the Procuring Activity.

Area of Coverage:

The MIL-STD is concerned with the management of a reliability program.

Constraints:

Only applied during the development and production of systems and equipment. Also applicable to Government agencies involved in the development of hardware.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides for a design discipline which allows for the determination and control of MTBF figures. The MTBF figures are used to determine demand rates for test equipment.

NOTES

MIL-STD-785A, 28 March 1969, Reliability Program for Systems and Equipment Development and Production

User: DOD

The MIL-STD is concerned with the management of reliability programs. This is specified in the contents of a reliability program plan, associated sub-tier documents and data items.

This MIL-STD relates to the test engineer in the MTBF parameter. The MTBF parameter is used to determine demand rates for use of the ATE/test equipment.

Document: MIL-STD-1326

Date: 15 January 1968

Title: Test Points, Test Point Selection and Interface Requirements
for Equipment Monitored by Shipboard On-Line Automatic Test
Equipment

User: Navy

Major Topics: Test Points, Interfaces, Data Requirements

Level of Detail:

Specifies selection of test point requirements and submission of data.

Area of Coverage:

Hardware requirements and documentation.

Constraints:

This document is only applicable to shipboard on-line equipment.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides general design criteria for shipboard on-line equipment.

Document: MIL-STD-1345A(EC)

Date: 21 March 1975

Title: Data, Measurement, in Support of Maintenance, Calibration, and Repair of Electronic Equipment

Custodian: Naval Electronic Systems Command

Major Topics:

This standard outlines the measurement data required in support of maintenance, calibration, and repair of electronic equipment, both on and off-line.

Level of Detail:

This standard establishes the information requirements for:

- (a) Identification of the measurement and stimulus parameters at specific nodes and test points in electronic systems and equipment.
- (b) Determination of the adequacy of measurement techniques.
- (c) Summarizing the total measurement requirements of electronic systems and equipments.
- (d) Determination of the minimum test, measurement, and diagnostic equipment which is required for operation, maintenance, calibration, and repair of electronic systems and equipments.

Area of Coverage:

This is primarily a design review data standard.

Constraints:

This standard is only for use by naval activities.

Overlap Between Documents:

This document performs the same general function, that of documenting the design (test requirements data), as MIL-STD-2076 and MIL-STD-1519.

Contribution Toward Testability:

The document provides for the standardization of measurement data (test procedures, block diagrams, schematics, etc.).

NOTES

MIL-STD-1345A(EC), 21 March 1975, Data, Measurement, in Support of Maintenance, Calibration, and Repair of Electronic Equipment

Custodian: Naval Electronic Systems Command

General Requirements:

Requires that measurement data be provided at various stages of equipment development.

Types of Data:

Preliminary and final data is to be supplied. Examples are given in an appendix.

Detailed Requirements:

This standard establishes the information requirements for:

- (a) Identification of the measurement and stimulus parameters at specific nodes and test points in electronic systems and equipment.
- (b) Determination of the adequacy of measurement techniques.
- (c) Summarizing the total measurement requirements of electronic systems and equipments.
- (d) Determination of the minimum test, measurement, and diagnostic equipment which is required for operation, maintenance, calibration, and repair of electronic systems and equipments.

In supplying the above information, the standard lays out the requirements for:

- 2.1 Equipment description - self explanatory.
- 2.2 Block diagrams - to include interfaces and signal flow between systems, subsystems, unit, assembly and subassembly.
- 2.3 Schematic diagrams - requires the data to show the connections to each electrical part used in the equipment.
- 2.4 Test procedures - step-by-step routines required for both organizational and depot test procedures. Covers performance test, fault isolation, and alignment procedures. Requires safety precautions, test set-up diagrams, listing of test equipment, and records of test data.
- 2.5 Information on both special purpose electronic test equipment (SPETE) and nonstandard general purpose test equipment (GPTE).
- 2.6 Built-in test equipment (BITE) information outlines in general terms.
- 2.7 Instrumentation summary - requires a summary of instrumentation to align, verify performance and locate faults in prime equipment.

- 2.8 Maintenance tools summary - requires a list of those tools required to maintain the equipment.
- 2.9 Test fixture information - self explanatory.
- 2.10 Measurement parameters - requires a tabulation of general and special parameters used for each item. The standard lists these specifically in 12 pages of parameter data.

Data Requirements

References the following Data Item Descriptions (DID):

- o DI-T-2126 Data, Measurement Technique Analysis
- o DI-T-2125 Data, Test Equipment/Tools/Test Fixtures

Document: MIL-STD-1364E(NAVY)

Date: 1 April 1979

Title: Standard General Purpose Electronic Test Equipment

Custodian: Naval Electronic Systems Command

Major Topics:

This document identifies standard and substitute standard general purpose electronic test equipment (GPETE) for Navy use.

Level of Detail:

This document contains extensive listings of GPETE cross-referenced several different ways. There are 10 separate appendices containing over 600 pages of listings.

Area of Coverage:

This standard is a management aid for use in locating items of electronic test equipment that are general purpose in nature.

Constraints:

This document is only applicable to standard and substitute standard GPETE.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides a list of GPETE for use in testing hardware.

NOTES

MIL-STD-1364E(NAVY), 1 April 1979, Standard General Purpose Electronic Test Equipment

Custodian: Naval Electronic Systems Command

General

This standard identifies standard and substitute standard general purpose electronic test equipment (GPETE) which have been determined to be suitable for Navy use and for which NAVELEX exercises material support responsibility by management of item entry in accordance with delegated Naval Material Command authority.

Detailed Information

The document contains a listing of all approved GPETE. It does not list:

ATE
SPETE
GSI
Limited Availability GPETE
Limited Demand GPETE
Non-standard GPETE
Calibration Equipment
Electrical Test Equipment

Appendices

There currently are a total of 644 pages in this document. All but six of these pages are contained in the appendices as follows:

- A. Cross Reference - Noun Name to Standard and Substitute Standard Equipments
- B. Cross Reference - Standard and Substitute Standard Equipments to National Stock Number
- C. Cross Reference - National Stock Number to Standard and Substitute Standard Equipments
- D. Cross Reference - All GPETE to Standard and Substitute Standard Equipment
- E. Cross Reference - Standard and Substitute Standard Equipment Nomenclature to Equipments Replaced
- F. Cross Reference - NAVSEC SCAT Code to GPETE
- G. Cross Reference - Federal Supply Code for Manufacturers to NAVSEC Manufacturers Code and Manufacturer Name
- H. Cross Reference - Manufacturers Code to Federal Supply Code for Manufacturers and Manufacturer Name

- I. Cross Reference - Manufacturers Name to Federal Supply Code for Manufacturers and NAVSEC Manufacturers Co
- J. Technical Information Sheets

Other Information

The standard also contains information on how a contractor can apply for listing of a piece of electronic test equipment.

Document: MIL-STD-1390B(NAVY)
Date: 1 December 1976
Title: Level of Repair
Custodian: Navy Weapons Engineering Support Activity

Major Topics:

This standard specifies methods, time phasing, and reporting requirements for performing Level of Repair (LOR) analysis for naval material. This document could be used for trade-off analysis for both off-line and on-line testing.

Level of Detail:

This document is a lengthy (243 pages) dissertation on the advantages of and the methodology/formulas for computing LOR as part of the Integrated Logistic Support (ILS) program.

Area of Coverage:

This standard is a management tool used in the acquisition of Naval Systems Command material. Also used for design trade-off studies.

Constraints:

This standard is only applicable to NAVAIR, NAVFLEET, and NAVSEA acquisitions.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides the means to perform design trade-off studies.

Document: MIL-STD-1519(USAF)

Date: 1 August 1977

Title: Test Requirements Document, preparation of

Custodian: Air Force

Major Topics:

Establishes the requirements for the preparation and control of the Test Requirements Documents (TRD) for off-line Units Under Test (UUT).

Level of Detail:

Specific instructions are included for the preparation and formation of a TRD. A sample is shown for each page type to be included in a TRD. Requires a complete description of all input conditions and measurements required to perform the test.

Area of Coverage:

This is a documentation requirements document for testability.

Constraints:

Applies only to electronic off-line UUT.

Overlap Between Documents:

This document performs the same general function, that of documenting the design (test requirements data), as MIL-STD-1345 and MIL-STD-2076.

Contribution Toward Testability:

The document provides for the standardization of test requirements data.

NOTES

MIL-STD-1519(USAF), 1 August 1977, Test Requirements Document, preparation of

Custodian: Air Force

General Requirements:

This document gives a detailed breakdown of the format and contents for Test Requirements Documents (TRD) for off-line electronic Units Under Test (UUT). Exact formats are shown for several sheets of a TRD. Specific contents and sequencing are specified for each sheet.

Detailed Requirements:

The document requires that a TRD be provided for each Replaceable Unit (RU), RU chassis, and RU subassembly.

General Test Requirements:

The TRD must provide the information that is required to:

- (a) test the performance of the UUT and indicate all faults and out-of-tolerance conditions.
- (b) adjust and align the UUT.
- (c) If the UUT is an RU, isolate all faults to the module or RU chassis.
- (d) If the UUT is a RU chassis or subassembly, isolate all faults to component level.

Types of Tests:

The document covers the following types of tests:

- (a) power/stimuli short tests
- (b) performance tests
- (c) diagnostic tests

Performance Characteristics:

Requires a detailed description of the performance characteristics and lists all the minimum information required.

Quality Assurance:

The document contains fairly standard inspection acceptance and validation requirements.

Documentation:

There are no specified documentation requirements (DIDs). The document in itself specifies the total requirements for a TRD.

Document:

MIL-STD-1657(SH)

Date:

30 April 1980

Title:

Switching Equipment, Combat System, Command and Control, and Fire Control, Requirements for

Custodian:

Naval Sea Systems Command

Major Topics:

This standard covers the requirements for the design of switching equipment used to control the interfaces and to monitor the operation of equipment components.

Level of Detail:

This is a detailed design standard for new or modernized switching equipment for ships. It contains details for 20 different requirements for various type pieces of switching equipment.

Area of Coverage:

This is a requirements document, primarily in the area of physical interface.

Constraints:

The standard is applicable to NAVSEA only.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

This document provides standard interfaces (primarily physical).

NOTES

MIL-STD-1657(SH), 30 April 1980, Switching Equipment, Combat System, Command and Control, and Fire Control, Requirements for

Custodian: Naval Sea Systems Command

General Requirements:

This standard is applicable to new design switching equipment intended for new construction ships or modernized active Fleet ships.

Detailed Requirements:

The detailed requirements for configuration of various switching equipment are shown in 20 different "Requirements" attached to the standard.

- Requirement 1 - Termination of large conductor ship cables
- Requirement 2 - Synchro connections
- Requirement 3 - Taper pin blocks
- Requirement 4 - Terminal junction systems
- Requirement 5 - Panel-mounted assemblies
- Requirement 6 - Relay or relay and fuse panel assembly
- Requirement 7 - Fuse panel assembly
- Requirement 8 - Indicator light panel
- Requirement 9 - Bus selector switch panel
- Requirement 10 - Meter panel
- Requirement 11 - Switch potential transformer panel
- Requirement 12 - Fuse tester panel
- Requirement 13 - Relay tester panel
- Requirement 14 - Flasher panel
- Requirement 15 - Transformer panel
- Requirement 16 - Synchro signal converter
- Requirement 17 - Signal generator
- Requirement 18 - Switch panel
- Requirement 19 - Switch control and relay panel
- Requirement 20 - Detail schematic wiring diagrams

Document: MIL-STD-2076

Date: 1 March 1978

Title: UUT Compatibility with ATE, general requirements for

User: Naval Air Systems Command

Major Topics: Off-Line Design Documentation

Level of Detail:

The standard specifies general design requirements for WRA, SRA, and sub-SRA. The detailed requirements are in the form of the TRD. The requirements for the TRD are in the appendices.

Area of Coverage:

The primary area of coverage is the TRD with a limited validation section.

Constraints:

The standard is only applicable to the UUT for off-line ATE.

Overlap Between Documents:

This document performs the same general function, that of documenting the design (test requirements data), as MIL-STD-1345 and MIL-STD-1519.

Contribution Toward Testability:

This document provides for the standardization of test requirement data.

NOTES

MIL-STD-2076, 1 March 1978, UUT Compatibility with ATE, general requirements for

User: Naval Air Systems Command

General Requirements:

The MIL-STD presents design requirements for the UUT (off-line). The general requirements are performance verification and fault isolation for WRA, SRA, and sub-SRA.

Detailed Requirements:

Design for Test on ATE

Ambiguities are per AR-10 or the performance specification.

The use of other than a simple ID (reference MIL-STD-2077) require a deviation request.

The "Avionic Design Guide for VAST Compatibility" is specified.

The "Test Accessibility Guide for Army Mechanical Hydraulic and Pneumatic Material" is specified.

The design for test on an ATE is presented generally in the form of a design guide.

Test Points:

Access

Test points are to be through connectors except for "probe points" to resolve ambiguity requirements. The connectors are to AR-10. Test points are to be short circuit to ground proof.

Safety

Voltage levels, the use of barriers, and labels are specified in lieu of calling out a safety MIL-STD.

Sensitivity

Sensitivity is specified as being able to handle 10 feet of RG-188 and RG-195 cable.

Documentation:

The UUT/ATE test requirements documentation is as follows:

- (a) TRD (Test Requirement Data), Appendix A DID: UDI-T-21367A.
- {b) Deviations to the General Requirements section.
- (c) Problems to procuring activity as they become known.

Additional documentation is required for verification and is specified under "Quality Assurance".

Quality Assurance:

Verification

The verification of the ATE compatibility is based on approval of the following:

- (a) Test Requirements Data, Appendix A.
- (b) Review Team "Compatibility Task Scoring Data", Appendix B.
70% required for acceptance.
- (c) Normal Hardware Design Reviews (TRD Updates).
- (d) Test Phase - general statement to include as part of normal testing. Does not contain specific criteria.

Appendix A, TRD (Test Requirements Data)

The TRD is formatted per Appendix C.

The general requirements cover contents, handling of classified/proprietary data, UUT configuration changes, revisions and number assignments. The TRD is to cover the preproduction model and subject revisions. To be updated for first production model.

The remainder of Appendix A deals with the detailed requirements which represent a disclosure of all data (design, interface, support, etc.) for the UUT.

A test procedure and report for testability is not specified.

Appendix B, Compatibility Test Scoring Data

The appendix depicts a rating and scoring system for ATE compatibility.

Appendix C, TRD Format

This section lists the format for the TRD.

Appendix D, Summary Description of ATLAS

The ATLAS summary as presented here is concerned with a description of test requirements as opposed to test procedures and computer program structure. This is part of the TRD.

Appendix E, Application of UUT Failure Rate Data

This appendix provides the TPS development engineer with accountability of fault diagnostic ambiguity group vs fault isolation design criteria.

Appendix F, Fault Isolation (FI) Test Requirement, FI Data

This appendix requires the generation of functional and detailed flow-charts, and detailed test information sheets. The detailed test information is directly traceable to the ATLAS test procedure.

The FI section requires a validation by the supplier (submittal of a "validation certificate"). Validation is performed by test. The validation certificate contains the test results.

Document: MIL-STD-2077(AS)

Date: 9 March 1978

Title: Test Program Sets, General Requirements for

Custodian: Naval Air Systems Command

Major Topics:

Development requirements for off-line testing programs. Includes documentation, configuration management, quality assurance and preparation for delivery requirements to be followed by the contractor supplying the TPS.

Level of Detail:

Fairly detailed requirements for Test Programs (TP) including accuracy requirements, ATE communications, combining related to TP, use of BIT and BITE, contents of Test Program Instructions (TPI), supplementary data, and Interface Devices (ID). Detailed drawings and documentation requirements are included. Appendices are included showing the requirements for TPI outlines, supplementary data, master test program set index outline, Navy standardization of displayed messages for ATE, general change control procedure, and a sample fault insertion procedure.

Area of Coverage:

This document deals primarily with the documentation of testability requirements for test program sets.

Constraints:

The document is only applicable to procurement of test program sets.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

This document provides for the standardization of Test Program Sets (TPS).

NOTES

MIL-STD-2077(AS), 9 March 1978, Test Program Sets, General Requirements for
Custodian: Naval Air Systems Command

General Requirements:

This MIL-STD details how a contractor should prepare Test Program Sets (TPS) used in conjunction with an appropriate Automatic Test Equipment (ATE) to test Units Under Test (UUT). UUTs are defined as WRA, SRA, and SSRA.

Detailed Requirements:

Test Program (TP)

Shows eight (8) elements to be contained in a TP and explains what information each element should provide.

Quality Assurance (QA)

Directs a Quality Program Plan to assure that the software meets requirements.

TPS Evaluation

Two general ways - safety and cost effectiveness.

Safety

General statement that requires that safety features must be included. No specifics or reference to other standards.

Cost Effectiveness

Run times and universality covered.

Data Requirements

Lists ten (10) different deliverable items to provide the design and testing data as follows:

- a. Program Design Data
 - (1) Diagnostic Flow Chart
 - (2) Source/Object Program Listing
 - (3) Test Diagram
- b. ID Data Package
 - (1) Interface Device Drawings (UDI-E-21352)
 - (2) Pin List (UDI-T-21359A)

- c. ATG and TPS Source Deck in Standard Card Image Format (UDI-T-21360A)
- d. Computer Program Aids and Workarounds (UDI-T-21361A)
- e. Acceptance Test Procedures (UDI-T-21363A)*
- f. General Acceptance Test Procedures (UDI-T-21362A)*
- g. Acceptance Test Reports (UDI-T-21364A)
- h. Production Acceptance Test Specification (UDI-T-21365A)
- i. Program Plan (UDI-R-21407A)
- j. Test Strategy Report

TPS Validation and Verification

Refers to MIL-M-81203.

Guidelines

Directs that the "Program Design Hardware for Automatic Test Equipment" be used for the total process.

Appendix A - Test Program Instruction (TPI) Outline

Covers the format and content requirements for a TPI.

Appendix B - Supplementary Data

Supplementary is so defined to be inclusive of all that additional information essential to a full comprehension of the intent, structure, and interrelation of all elements of the TPS.

Covers the format and content requirements of this type data.

Appendix C - Master Test Program Set Index Outline

Provides instruction as to configuration and content of these indexes for VAST and VAST-supported weapon systems and equipment.

Appendix D - Navy Standardization of Displayed Messages for ATE

Contains the requirements and formats for standardizing the format of messages on the CRT, printer, or other ATE I/O media.

Appendix E - General Change Control Procedure

Configuration control procedures.

Appendix F - Sample Fault Insertion Procedure

Covers validation test (acceptance) for the TPS.

*These DIDs are erroneously listed as UDI-T-2163A and UDI-T-2162A, respectively in MIL-STD-2077, 9 March 1978.

Document: MIL-T-24309(SHIPS)

Date: 1 September 1967, Amendment 2 of 29 December 1967

Title: Technical Support Plan for Electronic Equipment

User: NAVSEA

Major Topics:

This specification requires the development of technical support plans for electronic equipment procured by or for the Naval Ship Systems Command.

Level of Detail:

This document outlines in fairly general terms the elements that are to be included in the technical support plan developed concurrent with the acquisition of shipboard electronic equipment. These elements are:

- (a) Maintenance concept
- (b) Plan for maintenance
- (c) Reliability design data
- (d) Maintainability design data
- (e) Modular construction and assembly design data
- (f) Test point and test equipment data

Area of Coverage:

The area of coverage of this specification is the documentation of design review data.

Constraints:

This document is only applicable to the acquisition of shipboard electronic equipment during the research and development and production phases.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides for the collection of data that will be used to support electronic equipment.

NOTES

MIL-T-24309(SHIPS), 1 September 1967, Amendment 2 of 29 December 1967,
Technical Support Plan for Electronic Equipment

User: NAVSEA

General Requirements:

Requires a contractor to develop a technical support plan based on those requirements of MIL-E-16400 which affect the technical support of the equipment. The plan shall consist of the following elements:

- (a) Maintenance concept
- (b) Plan for maintenance
- (c) Reliability design data
- (d) Maintainability design data
- (e) Modular construction and assembly design data
- (f) Test point and test equipment data

Detailed Requirements:

The body of the specification outlines the contents of each of the above mentioned elements. The Appendix contains a "sample format for technical support plan report". The sample gives a more detailed breakout of the contents of each of the six elements.

Maintenance Concept

This section is to contain a brief statement of the overall concept used as guidance in the design of the equipment to facilitate Fleet maintenance. This section should also contain how the concept was developed and what trade-offs were made to assure that the reliability and maintainability requirements are achieved.

Plan for Maintenance (PFM)

This section requires the contractor to present his PFM for: preventive maintenance; logistic support; repair facilities; and operator and maintenance personnel.

Reliability Design Data

Requires the documentation of reliability activities required by MIL-STD-785, MIL-STD-756, and MIL-R-22732 as specified in the individual equipment specifications.

Maintainability Design Data

Requires the documentation of maintainability activities required by MIL-STD-470, MIL-STD-471, and MIL-HDBK-472.

Modular Construction and Assembly Design Data

Requires a block diagram to the replaceable assembly level, and the data required by MIL-E-16400.

Test and Test Facilities Data

Requires that each area requiring test points and support equipment be described in this area and include the:

- (a) parameters to be measured.
- (b) required frequency of measurement.
- (c) minimum tolerances and accuracies necessary for proper operation.

Schematic Diagrams

Those that will aid in defining and describing areas requiring test points and support equipment, are required.

Unique Problems

Solutions to any unique problems are required. Functional and physical devices required are required to be identified along with their calibration parameters.

Test Facility Information

A complete breakout of requirements including physical characteristics is shown.

Test Points

Detailed listing of each test point requirement is listed.

Quality Assurance:

The provisions are fairly standard, although somewhat general, as to inspection requirements.

Document: MIL-T-28800B

Date: 9 February 1976

Title: Test Equipment for use with Electrical and Electronic Equipment; General Specification for

Custodian: Naval Electronic Systems Command

Major Topics:

This specification describes the general requirements for test equipment used in testing electrical and electronic equipment. Equipment covered includes general purpose, special purpose, peculiar, console mounted, automatic test equipment (ATE) and built-in-test equipment (BITE).

Level of Detail:

This document is a general requirements summary to be used in conjunction with the detailed specification for a piece of electrical/electronic test equipment. There is extensive cross-referencing to the specifications and standards for details (environmental, hardware, etc. requirements).

Area of Coverage:

This specification is a hardware requirements document to be used in the acquisition of appropriate test equipment.

Constraints:

Applicable to all electronic/electrical test equipment, primarily within the naval community.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides design requirements for test equipment. This document performs the same function as MIL-E-5400 and MIL-E-16400.

Document: NAVMATINST 3960.9A

Date: 23 April 1979

Title: Built-In-Test (BIT) Design Guide

Custodian: Naval Ocean Systems Command

Major Topics:

The Design Guide presents the fundamentals of BIT; provides an overview of the different approaches and requirements available to the designer and the acquisition manager; and discusses standardized methods for evaluation of these different approaches. This Guide should be invaluable for the personnel responsible for test, maintainability, reliability, and logistics support of present and future systems.

Level of Detail:

This guide is a lengthy and comprehensive aid that covers BIT categorization, requirements analysis, specifications, and specific examples of BIT design techniques.

Area of Coverage:

The guide is an implementation aid.

Constraints:

This is a management aid that is non-directive in nature.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

This document will aid a contractor in the implementation of BIT requirements.

Document: MIL-STD (W. Keiner), number to be assigned.
Date: 15 February 1980
Title: Testability Standardization for Electronic Systems and Equipment, W. Keiner

User:

Major Topics: Testability Standardization

Level of Detail:

The proposed MIL-STD specifies the requirements for a Testability Program Plan, analysis of the design, a testability demonstration, and evaluation of testability during OT&E.

Area of Coverage:

The proposed MIL-STD covers all areas as follows:

1. Management of Test Program (Testability Program Plan)
2. Hardware Requirements
3. Design Guide
4. Documentation of Testability (Testability Analysis Report)
5. Proof of Testability (Testability Demonstration)

Constraints:

Only used for hardware development.

Overlap Between Documents:

This document overlaps with MIL-STD-470 and MIL-STD-471. The classical approach to testability is maintainability. There may be conflict in the area of the MTTR maintainability demonstration test.

Contribution Toward Testability:

This standard should help to establish "Testability" as a design discipline similar to maintainability, reliability, etc. This should also cause the contractor to place more importance on testability during the R&D phase of hardware development.

NOTES

MIL-STD (number to be assigned), 15 February 1980, Testability Standardization for Electronic Systems and Equipment, W. Keiner

User:

General Requirements:

This section of the document specifies general testability program requirements. Included are general requirements for design, evaluation (analysis and test) and documentation.

Detailed Requirements:

The detailed requirements are presented as follows:

1. Conceptual Phase, 5.1 Testability Requirements.
2. Validation Phase, 5.2 Testability Program.
3. Full Scale Development Phase, 5.3 Testability Program

NOTE: page 4 of MIL-STD-471A - DT&E, OT&E phase.

Conceptual Phase (5.1):

The material presented here is typical of the process that would be used to generate the Request for Proposal (RFP). This may or may not be prepared by a contractor. This is separated into Operational Requirements (5.1.1), Requirements Trade-Offs (5.1.2) and Preliminary System Specification (5.1.3).

Validation Phase (5.2):

The validation phase covers the preliminary design phase. The topics discussed are: Testability Program Plan (5.2.1), Design Requirements and Trade-Offs (5.2.2), Analysis of Inherent Testability (5.2.3), and Preparation of Development Specification (5.2.4). The "testability program plan" section specifies the contents which are to be supplied by the contractor. The section on "design requirements and trade-offs" is general in nature. The "analysis of inherent testability" calls for a "preliminary Testability Analysis Report, Testability Analysis Models". This data is used to assess the testability of the design.

NOTE: Check this with the TRD in MIL-STD-2076 relative to design assessment.

The "preparation of development specification" section calls for testability requirements in the prime equipment development specifications, computer program development specifications, and ATE specifications. The specifications are to be reviewed at PDR.

Full Scale Development Phase (5.3):

This phase calls out a Test Requirement Document and Testability Analysis Reports. This section also calls out a diagnostic software specification.

The test effectiveness of the total design is analyzed through the following:

- o Functional analysis (end-to-end test)
- o Failure analysis (levels of failure detection and isolation)
requires failure modeling
- o Cost/benefit analysis

All of the analysis data are to be in the final Testability Analysis Report at CDR.

This section also calls out a "Testability Demonstration" per Appendix B with the results in the "Testability Analysis Report".

The final section (5.3.5) is concerned with "Operational Testability Evaluation". This is to be applied during OT&E.

General Comment: The full scale development covers the following:

1. Testability Program Plan
2. Analysis of the design
3. Testability Demonstration
4. Evaluation of testability during OT&E

Appendix A, Calculation of Failure Resolution

This appendix presents a method of calculating failure resolution using data from the test generation/failure simulation processes.

Appendix B, Testability Demonstration

This appendix details the testability demonstration. A testability demonstration plan is required (includes procedures).

Document: MIL-HDBK-217C

Date: 9 April 1979

Title: Reliability Prediction of Electronic Equipment

User: DOD

Major Topics: Handbook for Predicting the Reliability of Electronic Equipment

Level of Detail:

This handbook applies at the piece part level.

Area of Coverage:

This MIL-HDBK deals in the area of implementation (design guide) and documentation of the equipment reliability.

Constraints:

This MIL-HDBK is limited to electronic equipment. MTBF data is used by test engineers to determine demand rates for use of ATE/test equipment.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The document provides the data to determine the MTBF figures. These MTBF figures are used to establish demand rates for test equipment.

NOTES

MIL-HDBK-217C, 9 April 1979, Reliability Prediction of Electronic Equipment

User: DOD

This MIL-HDBK contains the failure rates for piece parts at different levels of stress and for different environments.

Document: MIL-HDBK-472

Date: 24 May 1966

Title: Maintainability Prediction

User: DOD

Major Topics: Maintainability Predictions

Level of Detail:

The application is to all levels of hardware from piece parts to complete assemblies or modules.

Area of Coverage:

The area of coverage is implementation as a design tool and documentation of the results for the design reviews. The areas of maintainability relative to testability are as follows:

- (a) The ATE or test equipment will detect a fault and isolate.
- (b) The amount of time required for the ATE or test equipment to detect and isolate a fault (plus retest), makes up part of the MTTR.

Constraints:

Involves the prediction of MTTR as a design tool, not directly involved with the design of ATE or test equipment. Areas that exhibit high MTTR figures are targets for re-design.

Overlap Between Documents:

There is no overlap between this document and the other documents reviewed.

Contribution Toward Testability:

The maintainability prediction allot's part of the MTTR times to detect, isolate and retest following a failure. This establishes design time limits on the test equipment.

NOTES

MIL-HDBK-472, 24 May 1966, Maintainability Prediction

User: DOD

The MIL-HDBK is concerned with the prediction of the maintainability parameters during specified stages of hardware design. The parameters of concern are the downtimes associated with hardware failure and for preventive maintenance. The downtime or repair time is generally segmented as follows:

- o Preparation - prepare to use ATE/test equipment.
- o Malfunction Verification - using ATE/test equipment.
- o Fault Location - results of using ATE/test equipment.
- o Part Procurement - logistic, obtain replacement.
- o Repair - remove and replace.
- o Final Malfunction Test - use of ATE/test equipment.

The general segmentation of repair times has been presented relative to the use of ATE. The maintainability engineer's interest relative to ATE is (1) will it work (fault isolate), and (2) how long does the ATE operation take?

The demonstration of these maintainability parameters is covered in MIL-STD-471A, Maintainability Verification/Demonstration/Evaluation.

The maintainability engineer's relationship with other disciplines is similar to that of the test engineer - primarily in the use of reliability. The parameter of interest is the MTBF.

The MTBF parameters are used to determine the demand rate for usage of the ATE by the test engineer. The maintainability engineer uses the MTBF parameters to target those areas of the design that require additional effort to reduce downtime.

The maintainability predictions are presented in four (4) different procedures. Each procedure is geared to application, airborne flight line, shipboard and shore electronics, Air Force ground equipment and mean and/or total corrective and preventive maintenance downtime of systems and equipment.

The results of these maintainability predictions are normally Contract Data Requirement Items (CDRL) and are presented in design reviews.

APPENDIX B

DOCUMENT REVIEW

APPENDIX B

This appendix contains deficiencies and recommendations for selected examples of MIL-documents. The following MIL-documents are presented:

- o MIL-STD-415
- o MIL-STD-454
- o MIL-STD-490
- o MIL-E-16400
- o MIL-T-28800
- o MIL-STD-2077/D-790 Comparison

MIL-STD-415D, 10 October 1969, Test Provisions for Electronic Systems and Associated Equipment, Design Criteria

Deficiencies

The document should be updated and Section 6, Notes, should be revised to exclude testability management functions and test requirements data. The testability management function (Para. 6.2 Ordering Data guidance meetings will conflict with a testability management MIL-STD (Proposed, W. Keiner). The need for test requirements data (Para. 6.3) conflicts with the test requirements data, and MIL-STDs.

Recommendations

Update the subject document to include quantitative numerical parameters and exclude the Notes, Section 6.0.

The following are general comments relative to updating MIL-STD-415D:

MIL-STD-415D:

Section/Paragraph

| | |
|---|--|
| 5.2.1.1 Accuracy | Need level of accuracy or ratio for measuring devise to parameter being measured. |
| 5.2.2.3 External receptacle(s) | Change: flush mounted or protected to allow placement of item on bench for roll over without damaging receptacle. |
| 5.2.3 BIT capability | Expand to include all of Section 3.1.g. |
| 5.2.3.1 Applicability of test provision classes | Add: "and or as required to meet the maintenance concept." |
| 5.2.4.3 External test points | Add: "the external electrical test points should not cause damage to the monitoring or operational circuits when shorted to ground." |
| 5.3.1 High voltage hazard | Reference Requirement 1 of MIL-STD-454. |

MIL-STD-415D (continued):

Section/Paragraph

5.3.2.3 Color Coding
of Test Points Reference Section 5, Electrical,
 of Requirement 1, MIL-STD-454.

6.0 Notes

6.1 and on Delete current notes.

MIL-STD-454F, 15 March 1978, Standard General Requirements
for Electronic Equipment

Deficiencies

MIL-STD-454 does not have a requirement that is dedicated to the subject of testability. It has Requirement 32, Test Provisions, that is associated with the hardware requirement, not the design discipline of Testability.

Recommendations

Draft a testability section for MIL-STD-454 that is design discipline oriented. The writing of a separate requirement titled Testability would place the design discipline of testability at the same level of importance as maintainability, reliability, safety, etc.

A testability requirement section of MIL-STD-454 could be as follows:

EXAMPLE

MIL-STD-454

REQUIREMENT XX

TESTABILITY

1. Purpose. This requirement establishes criteria for the application of testability principles and techniques.

2. Documents Applicable to Requirement XX:

MIL-STD-ABC - Testability Program Requirements (For Systems and Equipment)

MIL-STD-DEF - Testability Demonstration

MIL-STD-GHI - Testability Analysis and Report

3. Quantitative Testability. Quantitative testability requirements shall be as specified in the contract or in the end item system/development specification.

3.1 Quantitative Testability Demonstration. When required by the contract or end item specification, demonstration of the quantitative requirement shall be accomplished by test in accordance with MIL-STD-DEF or by analysis in accordance with MIL-STD-GHI.

4. Testability Program. When required in the contract or statement of work, the contractor shall establish, maintain and document a testability program in accordance with the guidelines of MIL-STD-ABC.

MIL-STD-490, 30 October 1968, Specification Practices

Deficiencies:

The subject MIL-STD does not contain the provisions for a testability section in the various specification types.

Recommendations:

Draft specific new sections for the various specification types. This includes a paragraph for the design Section 3 and for the quality assurance Section 4 of each specification type.

MIL-E-16400, Electronic Equipment, Naval
Ship and Shore, General Specification

Deficiencies

MIL-E-16400 does not contain reference to the specific subject of testability as a design discipline.

Recommendations

Draft testability sections for MIL-E-16400 that are design discipline oriented.

Testability would be placed on the same level as the other design disciplines of maintainability, reliability, safety, etc., by referencing a testability requirement of MIL-STD-454. This would include provisions for testability quantitative requirements, analysis and demonstration. See comments on MIL-STD-454.

MIL-T-28800B, 9 February 1976, Test Equipment for Use With Electrical and Electronic Equipment, General Specification for

Deficiencies:

MIL-T-28800 does not contain reference to the specific subject of testability as a design discipline.

Recommendations:

Draft testability sections for MIL-T-28800 that are design discipline oriented.

Testability would be placed on the same level as the other design disciplines of maintainability, reliability, safety, etc., by referencing a testability requirement of MIL-STD-454. This would include provisions for testability quantitative requirements, analysis and demonstration. See comments on MIL-STD-454.

This would require a change to MIL-T-28800 including Table XI, Examination and Test Groups.

MIL-STD-2077/D-790 Comparsion
MIL-STD-2077, Test Program Sets, General Requirements for
D-790, Test Program Sets, General Requirements for

The discussion, to follow, is a comparsion of the two Test Program Sets (TPS) documents.

Section 1. Scope. MIL-STD-2077 calls out "WRAs" whereas D-790 calls out "Replaceable Assemblies (RA)".

Section 3. Definitions. MIL-STD-2077 contains definitions for Test Accuracy Ratio, Test Program Set Integration, End-to-End Run Time and Average Isolation Time whereas D-790 does not.

Paragraph 4.1 Test Program Set. D-790 calls for "one ID Documentation" in addition to "one ID".

Paragraph 5.1.1.6.1. Design Requirements, in MIL-STD-2077 do not appear in D-790. This paragraph specified AR-10, WRAs, etc.

Paragraph 5.1.1.6.1. The Program Contents section in D-790 has the following additional requirement: "The TP shall isolate faults with an average fault resolution of two components".

Paragraph 5.1.1.7. Adjustment/Alignment Routine, D-790 uses RA in lieu of WRA.

Paragraph 5.3 ATE Communications. D-790 uses the term UUT whereas MIL-STD-2077 uses Avionic Set.

Paragraph 5.6 Utilization of BIT/BITE. Omitted from D-790.

Paragraph 5.7 Test Program Instruction. MIL-STD-2077 specifies TPI preparation per MIL-M-38784 whereas D-790 does not. MIL-M-38784 is "Manuals; Technical Requirements for, Preparation of".

Paragraph 5.7.2.1 Test Program Instruction Outline. MIL-STD-2077 utilizes VAST ATE as an example in Appendix A whereas D-790 does not.

MIL-STD-2077/D-790 Comparison (continued)

Paragraph 5.9 Interface Device. MIL-STD-2077 specifies a minimum MTBF of 1000 hours when calculated per MIL-HDBK-217 whereas D-790 does not discuss MTBF.

MIL-STD-2077 specifies MIL-T-28800, Type III, Class 4 equipment whereas D-790 only specifies workmanship per MIL-STD-454.

Paragraph 5.9.2 Maintainability. MIL-STD-2077 specifies AR-10 which is Avionics whereas D-790 does not.

Paragraph 5.9.3 Weight. MIL-STD-2077 specifies total weight of ID per MIL-STD-1472 whereas D-790 does not.

MIL-STD-1472 is for human factors.

Paragraph 5.9.4 ID Identification. MIL-STD-2077 specifies a visual identification requirement per MIL-N-18307 whereas D-790 has no requirement for visual identification.

MIL-N-18307 makes reference to "Aeronautical".

MIL-STD-2077 specifies Avionic set whereas D-790 deletes reference to the term avionic.

Paragraph 5.10 Drawings and Documentation. MIL-STD-2077 calls for Program Design Data (PDD) whereas D-790 does not. The PDD in MIL-STD-2077 specifies data from the Test Requirements Document (TRD per MIL-STD-2076). The PDD is the source documentation for the Test Program (TPs).

D-790 does not appear to be concerned with documenting the TPs.

Section 6 Configuration Management. MIL-STD-2077 calls out MIL-N-18307 under TPS part numbers whereas D-790 does not reference a MIL-STD.

MIL-STD-2077 specifies MIL-STD-480 for engineering change control whereas D-790 does not specify a MIL-STD.

MIL-STD-2077 specifies configuration control procedures for tape and tape related software in Appendix E. D-790 does not make reference to configuration control procedures for tape and tape related software.

D-790 deletes reference to the term avionic.

MIL-STD-2077/D-790 Comparison (continued)

Section 7 Quality Assurance.

Paragraph 7.3.3.1 Detection and Isolation Success. MIL-STD-2077 supplies an example of verifying the detection and isolation success (Appendix F). D-790 does not supply an example. In addition, MIL-STD-2077 specifies that unless otherwise specified, Appendix F will be used to verify detection and isolation success.

Paragraph 7.3.3.2 Program Run Times. MIL-STD-2077 calls out program run times as part of acceptance whereas D-790 does not.

Section 8 Preparation for Delivery. MIL-STD-2077 specifies MIL-E-17555 for physical protection. MIL-E-17555 is a packing and packaging specification.

D-790 does not discuss physical protection.

Section 9 Notes. MIL-STD-2077 is more definitive than D-790.

MIL-STD-2077 makes provisions for proof testing (Data Items - test procedures and reports) whereas D-790 does not.

Appendix A - Test Program Instruction (TPI) Outline. MIL-STD-2077 references five (5) MIL-level documents while D-790 lists none.

D-790 is less definitive than MIL-STD-2077.

Appendix B - Supplementary Data. MIL-STD-2077 references six (6) MIL-level documents while D-790 lists none.

Appendix C in D-790 is like Appendix D in MIL-STD-2077, NAVY Standardization of Display Messages for ATE, but not as definitive.

Appendix C in MIL-STD-2077 is, "Master Test Program Set Index Outline".

Appendix E and Appendix F are in MIL-STD-2077, but not in D-790.

In MIL-STD-2077, Appendix E is "General Change Control Procedure" and Appendix F is "Sample Fault Insertion Procedure".

D-790 contains the following: Supplement I (Digital) to NAVELEX STD No. D-790

This supplement is definitive, but applies only to the Phoenix Test Equipment.

APPENDIX C

TESTABILITY DIDs

| DATA ITEM DESCRIPTION | | 2. IDENTIFICATION NO(S) | |
|----------------------------------|---|--|-----------|
| | | AGENCY | NUMBER |
| 1. TITLE | Testability Program Plan | Army | DI-A-XXX1 |
| 3. DESCRIPTION/PURPOSE | This plan is used by the procuring activity to evaluate the contractor's program for incorporating, monitoring and evaluating testability considerations in the development of systems and equipments. | 4. APPROVAL DATE | |
| 7. APPLICATION/INTERRELATIONSHIP | This Data Item Description is applicable to system development contracts during the conceptual phase, exploratory development phase, or advanced development phase. It may be used to define testability program plans to be submitted in response to an RFP. | 5. OFFICE OF PRIMARY RESPONSIBILITY | |
| 10. PREPARATION INSTRUCTIONS | The testability Program Plan shall present the overall testing strategy including operational checks, periodic on-line tests, and off-line test considerations. It shall present milestones to be met to ensure that the final design achieves the required degree of testability. The plan includes the mechanisms for the reporting of progress, problems, and tradeoffs, and the enforcement of the proper use of testability design features by designers and subcontractors. The plan shall include the following: a. The work to be accomplished for each task referenced in DD Form 1423. b. Program milestones and customer reviews. c. The contractor organizational element responsible for the implementation of the Testability Program. d. Interfaces between that responsible organizational element and related elements such as: Systems engineering Design engineering Maintainability engineering Logistics Support equipment Training Operational software Diagnostic software Maintenance documentation Test Reliability engineering e. Control over subcontractor and vendor testability programs. | 6. DDC REQUIRED | |
| | | 8. APPROVAL LIMITATION | |
| | | 9. REFERENCES (Mandatory as cited in block 10) | |
| | | MCSL NUMBER(S) | |

| DATA ITEM DESCRIPTION | | 2. IDENTIFICATION NO(S) | |
|---|--|--|--------|
| | | AGENCY | NUMBER |
| 1. TITLE Testability Analysis Report | | Army | |
| 3. DESCRIPTION/PURPOSE This report is used by the procuring activity to evaluate the contractor's design of testability features into systems and equipments and to provide data to assist in predicting maintainability and availability levels and in determining support requirements. | | 4. APPROVAL DATE | |
| 7. APPLICATION/INTERRELATIONSHIP This Data Item Description is applicable to system development contracts requiring the establishment of a Testability Program. It may be used to define qualitative testability design data to be submitted during the validation phase. It may be used to define quantitative testability design data to be submitted during the full scale development phase. | | 5. OFFICE OF PRIMARY RESPONSIBILITY | |
| 10. PREPARATION INSTRUCTIONS 1. The qualitative sections of the Testability Analysis Report shall include: a. A description of the partitioning used to enhance testability in accordance with technical requirements referenced in DD Form 1423. b. A description of each applicable item. c. An analysis of potential failure modes and effects for each item. Data for the analysis and failure rates and confidence levels may be referenced from the Reliability Program, as is applicable. d. A summary of the overall maintenance concept taken from the Maintainability Program and ILS Plan. A description of the overall test strategy to implement the maintenance concept, including coordination between BIT and ATE. e. A description of the test strategy to be used for each applicable item, as determined by the overall test strategy. f. A functional description of built-in test features, including hardware and software RIT, and testability features, including controllability and observability considerations, for each item. g. A functional description of testability measurement techniques to be used, including computer-aided analysis tools. 2. The quantitative sections of the Testability Analysis Report shall include: a. For each item defined in 10.1.b, a description of the Testability Analysis Model including: [1] A definition of the failure population in accordance with the specification. [2] Identification of the test stimulus, including built-in test stimulus and external stimulus. [3] A determination of the percentage of failures in the failure population which are detected by the test stimulus. | | 6. DDC REQUIRED | |
| | | 8. APPROVAL LIMITATION | |
| | | 9. REFERENCES (Mandatory as cited in block 10) | |
| | | MCSL NUMBER(S) | |

DI-R-XXX2 Testability Analysis Report

Preparation Instructions (Continued)

- [4] A determination of the level of fault isolation achievable with the test stimulus.
- [5] The justification for classes of failures remaining undetected or which are poorly isolated.
 - b. For the overall system,
 - [1] A description of the integration of the items and their test stimulus/response at the system level.
 - [2] A determination of the overall system fault coverage and level of fault isolation based upon an appropriate combination of these characteristics for each item.
 - [3] An estimate of developmental and recurring costs associated with design for testability, including weight, volume, and reliability penalties, and increased computer memory requirements.
 - [4] An estimate of developmental, production, and support savings associated with design for testability, including reduced checkout time, training, spares, and ATE costs.

16 February 1980

SUPPLEMENT TO DI-R-XXX2
TEST PROVISIONS, ANALYSIS AND SELECTION

1. The design of Class A, B, C, and D test provisions, per MIL-STD-415D, shall be based on an analysis of electrical circuit operational characteristics and failure modes. This shall consist of an analysis of the probable failure modes at every failure in terms of measurable values. Likely failures resulting from drift, degradation, and instabilities shall be included in the analysis.

2. Data requirements for test provisions shall include the following:

a. The Contractor shall provide the physical, functional, and electrical locations of the test provisions on functional block diagrams, circuit schematics, and pictorial media, as specified herein. The results of the failure mode analysis which was the basis for the electrical location of the test provisions shall be described in detail, referencing the specific test provision(s). Sufficient information shall be provided to permit government reviewing personnel to determine the type, amount, and configuration of test provisions proposed to support the item and to allow for positive identification of the test provisions on circuit schematics and pictorial media.

b. The Contractor shall prepare a functional block diagram of the end item, identifying item, nomenclature, part number with description, operational functions, test capabilities provided, and, where test provisions terminated in electrical connectors, the connectors shall be identified in accordance with USAS-Y 32.16-1965, and their physical location shall be indicated.

c. The Contractor shall also prepare additional functional block diagrams of item identifying Class B and C test provisions and circuit schematics identifying Class D test provisions. The block diagrams and circuit schematics shall identify the electrical characteristics for each test parameter (functional entity) along with tolerance limits and the test termination in the test connector (receptacle) by pin number. The term "functional entity" as used in this document is intended to identify circuits required to perform a specific function such as, IF or AF amplifier, oscillatory power supply circuits, and so forth used in checking normal or abnormal performance. Furthermore, pictorial media will show and identify Class B, C and D test provisions.

d. The Contractor shall prepare a table of information which can be directly correlated with the test provision information included on the block diagrams and circuit schematics. The table shall include, but not be limited to, such information as listed below:

SUPPLEMENT TO DI-R-XXX2 (CONT)

- (1) Tolerance
- (2) Test provision interrelationships
- (3) Impedances
- (4) Ground returns
- (5) Loading
- (6) Waveforms

(7) Test provisions describing inputs and outputs of digital card logic will be by precise and non-varying truth tables. Tolerance limits will be specified for all logical high states and logical low states.

e. The Contractor shall prepare a brief theory of operation for the end item which shall be of sufficient engineering detail to permit a clear understanding of the information incorporated in the diagrams.

3. Maximum use shall be made of the drawing requirements data generated under this contract.

| DATA ITEM DESCRIPTION | | 2. IDENTIFICATION NO(S) | |
|---|--|---|---|
| | | AGENCY | NUMBER |
| I. TITLE | Test Requirements Document | USAF | DI-T-3734A |
| 3. DESCRIPTION/PURPOSE | This item is used to identify performance and diagnostic test data. These data are used in the preparation of test packages (e.g., tapes, tape manuals, and interface items) or test procedures for automatic, semi-automatic, or manual test equipment. The Test Requirements Document (TRD) specifies the tests and test conditions required for performance testing and fault diagnosis of an end item. All test parameters and test conditions shall be independent of any specific test equipment. | 4. APPROVAL DATE | 18 May 1977 |
| 7. APPLICATION/INTERRELATIONSHIP | This data item shall apply to newly designed avionic end items. It shall also apply to existing avionic end items selected for testing on automatic, semi-automatic, or manual test equipment for which TRDs do not exist. The TRD shall be prepared as a four-part document. Part A is a summary of the detailed testing requirements that appear in Part B and Part C and is used in the preparation of Support Equipment Recommendation Data (SERDs). Part B contains the performance tests required to verify correct operation of an end item. Part C contains the diagnostic tests, used in conjunction with the performance tests, required to diagnose faults in an end item. Part D contains ATLAS (Abbreviated Test Language for All Systems) procedures which are used in the preparation of test packages/procedures. This DID supersedes DI-T-3734. | 5. OFFICE OF PRIMARY RESPONSIBILITY | AFSC/TE |
| 10. PREPARATION INSTRUCTIONS | The contractor shall prepare Part A, Part B, Part C, and Part D TRDs for each LRU, SRU and repairable assembly in the avionic subsystems of the aircraft. TRDS shall be prepared in accordance with MIL-STD-1519 and the following instructions: | 6. DDC REQUIRED | |
| a. | Part A TRDs shall be prepared as a summary of the total testing requirements for an end item. The testing parameters shall be in accordance with the requirements of 5.4.2.1 (minimum data requirements for UUT input conditions) and 5.4.2.2 (minimum data requirements for UUT output measurements) of MIL-STD-1519. | 8. APPROVAL LIMITATION | |
| b. | Part B TRDs shall be prepared to provide the performance tests for an end item. The performance tests shall be in accordance with the testing requirements summary specified in the Part A TRD and the requirements of 5.2.2.b (Performance Tests) of MIL-STD-1519. | 9. REFERENCES (Mandatory as cited in block 10) | MIL-STD-415 MIL-STD-806 MIL-STD-12 MIL-STD-15 MIL-STD-100 MIL-STD-1519 (USAF) IEEE-STD-416-1976 |
| c. | Part C TRDs shall be prepared to provide the diagnostic tests for an end item. The diagnostic tests shall be in accordance with the testing requirements of the Part A TRD, the performance tests of the Part B TRD and the requirements of 5.2.2.c (Diagnostic Tests) of MIL-STD-1519. | MCSL NUMBER(S) | |
| d. | Part D TRDs shall be prepared to provide ATLAS procedures for Part B and Part C TRDs. The Part D TRDs shall be prepared in accordance with IEEE Standard 416-1976, ATLAS test language. | | |

3 March 1980

SUPPLEMENT 1 (ILS)

TO

DI-T-3734A, TEST REQUIREMENTS DOCUMENT

Block 10, Preparation Instructions, of DI-T-3734A is changed to read as follows:

"1. General Requirements - The contractor shall prepare Test Requirements Documents (TRDs) in accordance with the following instructions for each peculiar Module and subassembly (printed circuit board (PCB)) of the system which shall be tested at General Support and/or Depot level. Each TRD shall be identified by a separate document number.

2. TRD Format - The TRD shall consist of a cover sheet attached to one or more sheets of test requirements and additional sheets and/or explanatory notes as required. Standard engineering terms, symbols and abbreviations shall be used in the TRD. Terminology subject to interpretation shall be defined in the General Data section of the TRD.

a. Cover Sheet - The cover sheet shall identify the TRD and the Unit-Under-Test (UUT) to which it applies. In lieu of classifying each TRD, all classified data may be incorporated into a single document which is referenced by paragraph in the applicable TRD. The name of the actual contractor preparing the TRD and the name of the prime contractor for which the TRD was prepared shall be noted.

b. General data shall be provided in accordance with paragraph 3.

c. Performance Characteristics descriptions shall be provided in accordance with paragraph 4.

d. Detailed Test Information data shall be provided in accordance with paragraph 5.

e. Revisions - Changes to the TRDs that are necessary due to errors, omissions, and improvements shall be submitted as revisions to the applicable data document. These changes shall include a new cover page, a new revision index and all changed pages.

f. MIL-STD-1345B shall be used as a guide in preparing the TRD.

3. General Data - The following general UUT data shall be provided:

a. A description of circuit function.

b. General UUT physical characteristics.

Supplement 1 (ILS) to DI-T-3734A

c. Power Requirements - All UUT input power source requirements shall be specified, including ac and dc voltages and tolerances, nominal load current, frequency and tolerances, power supply source impedance, ground returns, ripple limits on dc voltages. When three phase power is required, the line-to-line voltages or line-to-neutral voltage must be so identified. Maximum allowable line-to-line unbalance and percent distortion must be specified.

d. Environmental Requirements - Special operating environmental conditions shall be defined. Describe cooling/pressurization requirements in practical terms as required for bench testing.

e. General Test Data - General procedures and precautions which apply to the test procedures as a whole to assure proper test conditions shall be specified in a General Test Data section.

4. Performance Characteristics - A detailed description of the performance characteristics shall be provided for each module and PCB in the system. Information shall be provided consisting of the functional name and Vendor's part numbers, input data, output data, test point data, and controls and ranges of controls (or adjustments) as applicable.

a. Input Data - All inputs, electrical optical, mechanical, etc., shall be defined and their range specified.

b. Outputs Data - All outputs shall be specified in terms of their range, accuracy and relationship to the input conditions.

c. Test Point Data - The test points shall be identified by function and relationship with input (and/or output) conditions shall be specified.

Input, output and test point data shall be identified by test connector and pin designation.

5. Detailed Test Information - Each required test to be conducted on UUT to determine whether it is functioning properly shall be explicitly detailed.

a. Test Data Format/Content - The detailed test information shall include the following data as applicable: test number, type of test (static, performance, diagnostic), test conditions (input power, stimuli, other), and measurement data such as:

Measured value high and low limits,

Supplemental data (operator action, parameter characteristics, time delays).

b. Detailed Test Data Requirements - The following data shall be provided for each test to be conducted on the UUT as applicable:

Supplement 1 (ILS) to DI-T-3734A

- (1) All input, output and return connections shall be specified by connector and pin number at the UUT. Each test condition shall include amplitude, frequency, phase, polarity, input impedance (load current in lieu of impedance for power input is acceptable) power level pulse repetition frequency, period, pulse width, rise and fall times, dc level, etc., as applicable. Time or phase dependent relationships shall be clearly defined using a diagram for clarity as needed.
- (2) Individual test requirements such as signal conditioning, loads and impedance matching terminations shall include nominal values, power ratings, voltage standing wave ratio (VSWR), etc. Complex loads shall be specified in standard engineering units.
- (3) Each waveform shall include characteristics such as polarity, baseline, period, amplitude, rise and fall times, etc. Only the characteristic to be checked shall appear in the measured value date section, all others in the supplemental data section. Each waveform (except sine waves) shall be described by pictorial illustrations.
- (4) Tolerances for every characteristic shall be specified. The upper and lower tolerance limits shall be described in the same units as the characteristic. Such terminology as less than or greater than shall be avoided when significant high and low limits can be specified. The expressions open circuit and short circuit may be used if explicitly defined.
- (5) Specify input and out put impedances of the UUT.
- (6) Any critical or unusual test requirement non self-evident elsewhere shall be clearly defined. Such requirements might include susceptibility to noise or transients, time delays before making measurements, signal and power lead characteristics, etc.
- (7) All adjustments which may correct a No-Go condition or optimize a critical parameter.

Conditions common to a group of tests, such as power input requirements stimuli, etc., may be listed on the first test of the group and back referenced on each of the remaining tests in the group.

c. Guidelines - The following guidelines shall be followed when preparing detailed test information.

- (1) The specification of ac voltages shall include a notation of root-mean-square (RMS), peak or peak-to-peak, and shall always include frequency and percent distortion when significant.

Supplement 1 (ILS) to DI-T-3734A

- (2) Pulse width measurements shall be normally specified at the 50% amplitude level. When deviation from this is required, the amplitude level shall be clearly identified.
- (3) Rise and fall times shall be normally specified between the 10% and 90% levels. When deviation from this is required, the amplitude levels shall be clearly specified.
- (4) Spikes, overshoots, undershoots, noise levels and dc levels shall be explicitly identified or illustrated.
- (5) Waveforms shall include a sync signal reference.
- (6) Resistance measurements involving semiconductor devices shall include polarity requirements and current flow limitations.
- (7) Measurements that require longer than 50 milliseconds for stabilization after input insertion or other action shall be so noted on the individual test specification sheets.
- (8) It is recognized that certain component failures or degradations may not be readily detectable during performance testing, such as power input filters and relay coil noise suppressors. The TRD should include functional tests to ensure that all such items are checked and failures detected whenever possible.
- (9) The specification of input/output test requirements at interface hardware test points instead of at the UUT shall be avoided.

END
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